Modeling the spreading of glacial melt water from the Amundsen and Bellingshausen Seas

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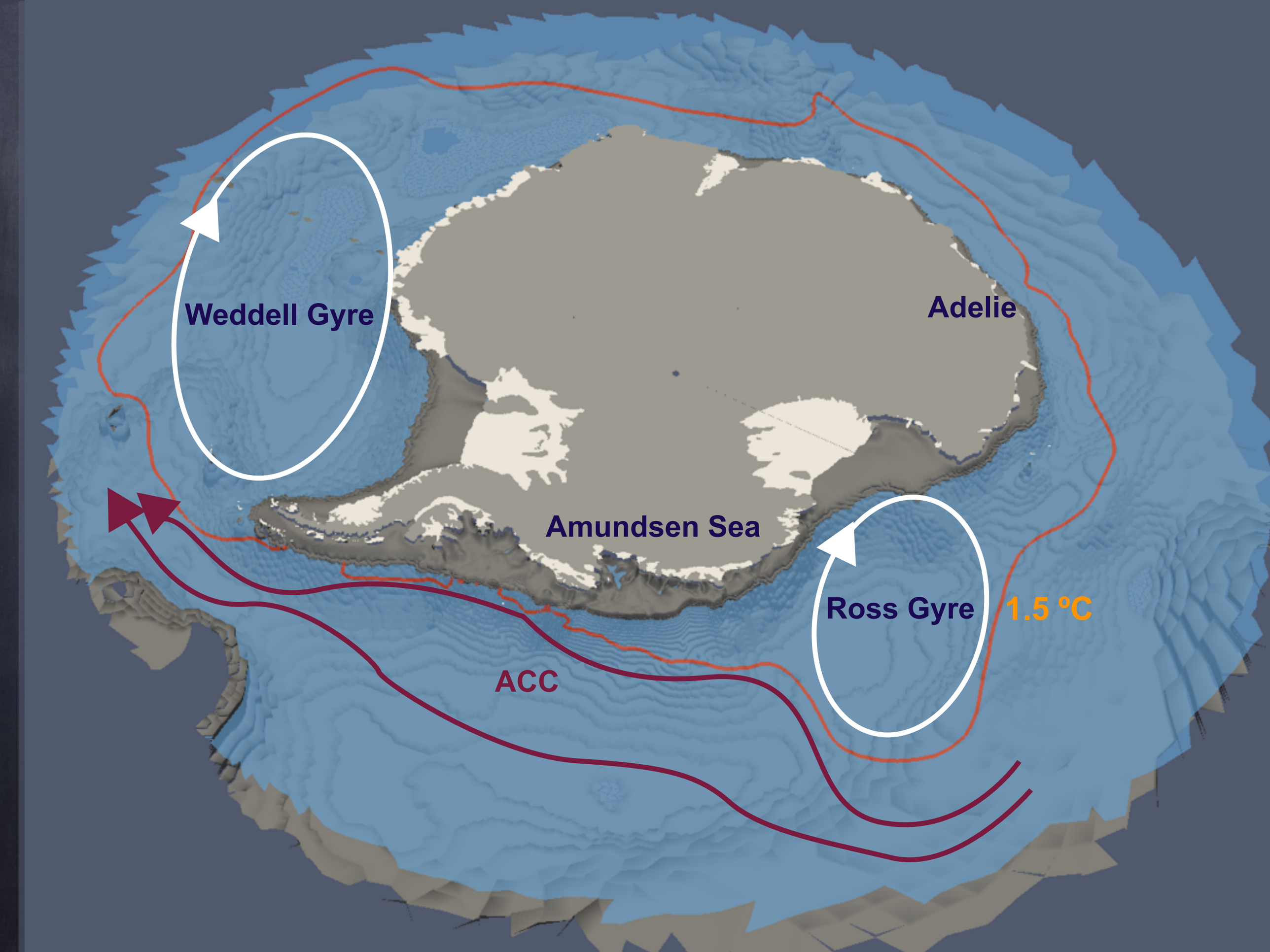
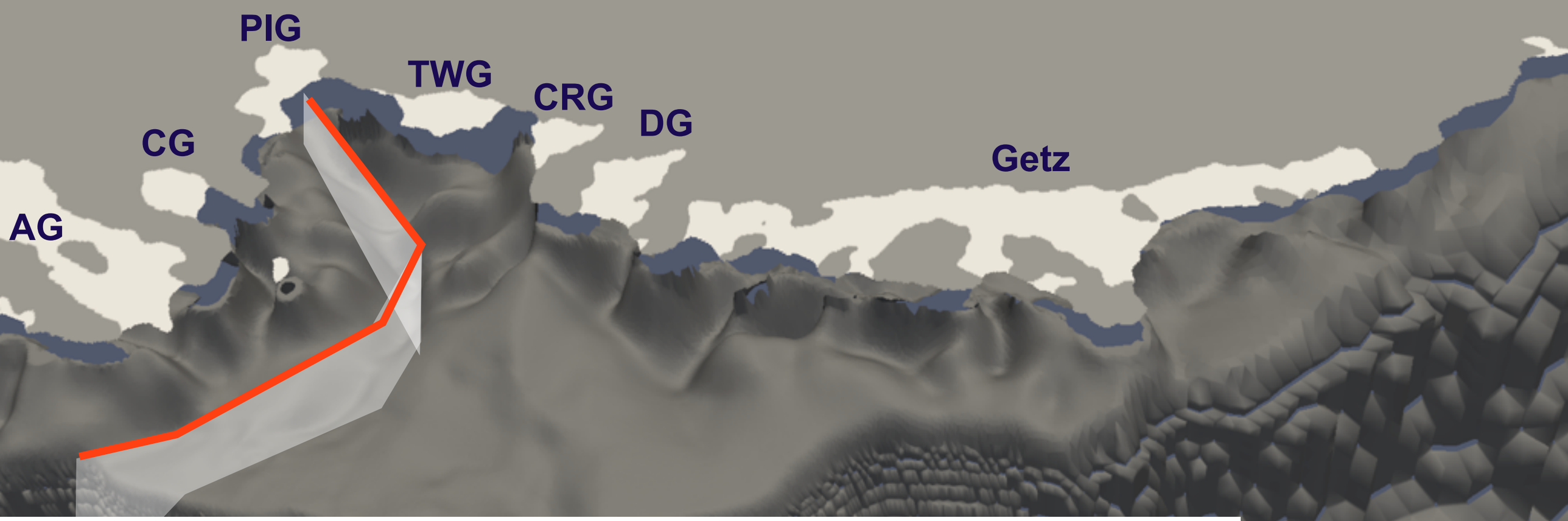
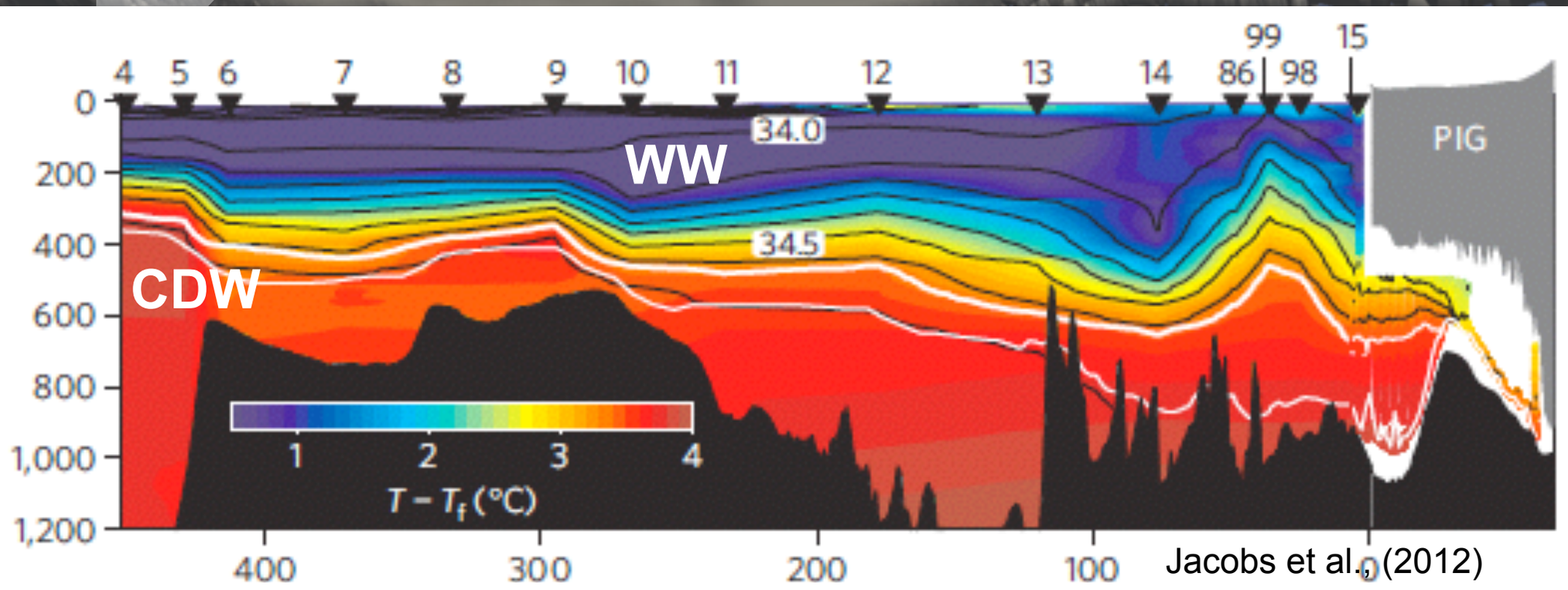

Weddell Gyre
Adelie
Amundsen Sea
Ross Gyre
1.5 °C
ACC

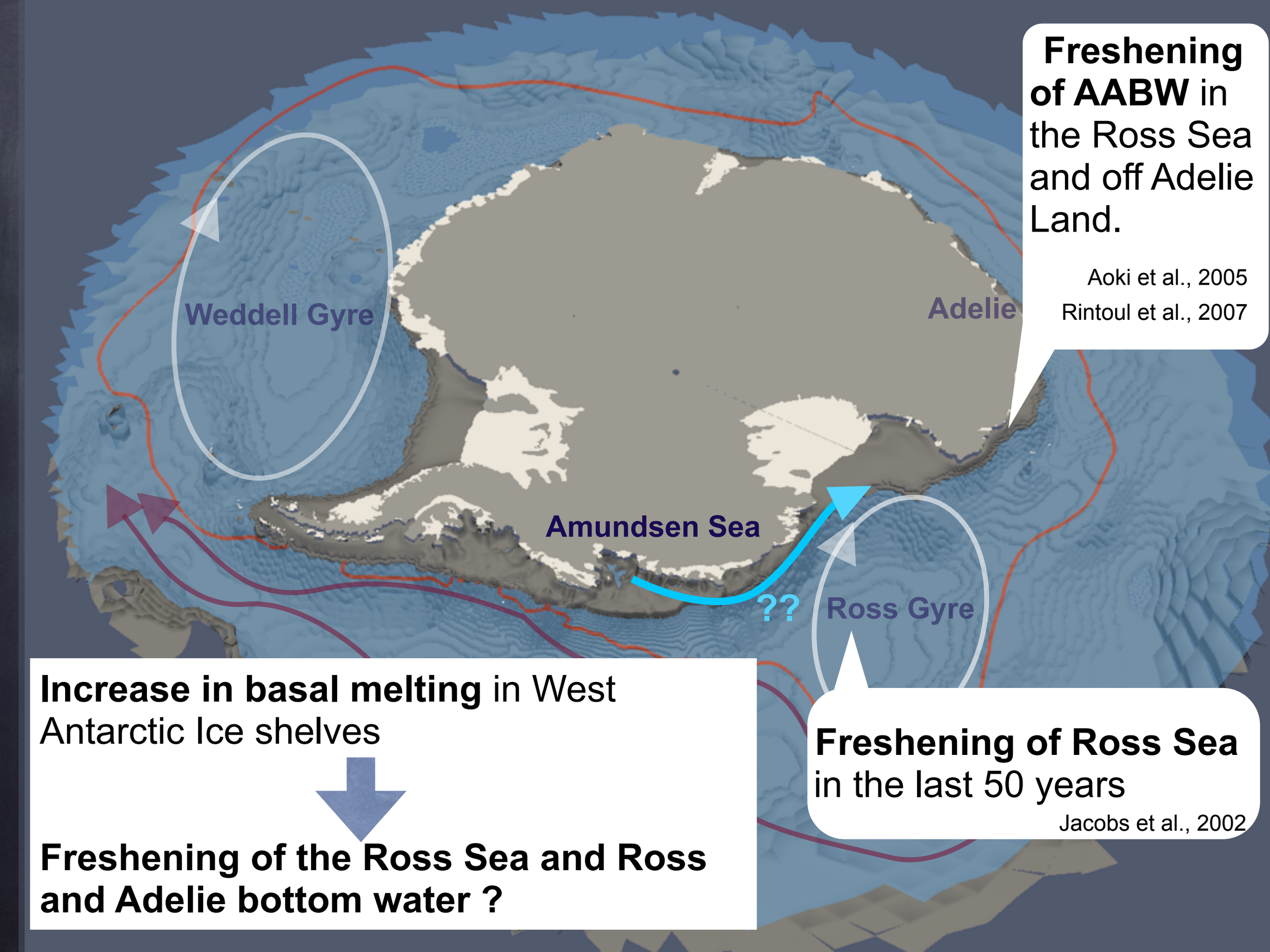
How does warm CDW carried by ACC flows onto the continental shelf ?





Jacobs et al., (2012)

“Stable” inflow of Circumpolar Deep Water (CDW)



Freshening of AABW in the Ross Sea and off Adelie Land.

Aoki et al., 2005

Rintoul et al., 2007

Increase in basal melting in West Antarctic Ice shelves

Freshening of the Ross Sea and Ross and Adelie bottom water ?

Freshening of Ross Sea in the last 50 years

Jacobs et al., 2002

Motivation

- Why global models make Amundsen Sea too cold ?
- Does spreading of glacial melt from West Antarctic Ice shelves cause freshening of the Ross Sea?

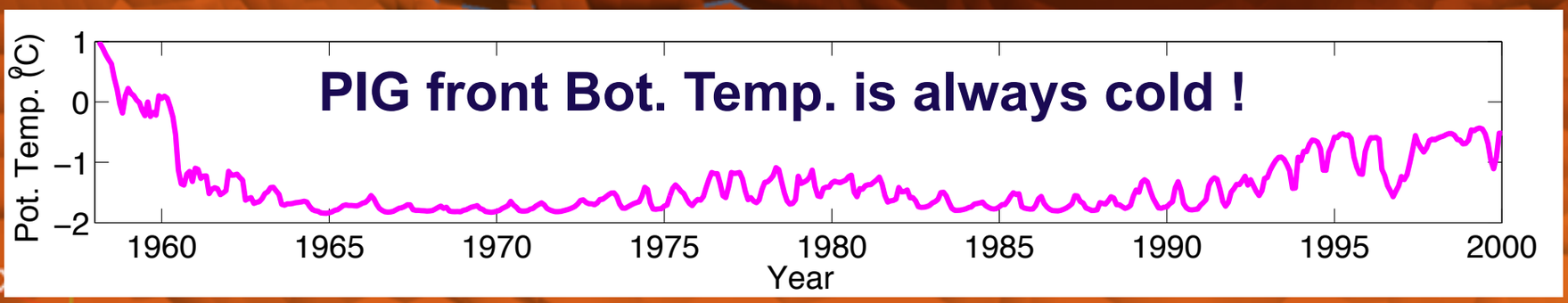
Bottom Pot. Temp. Timmermann et al., 2012

Ross

PIG

AG

Getz



T

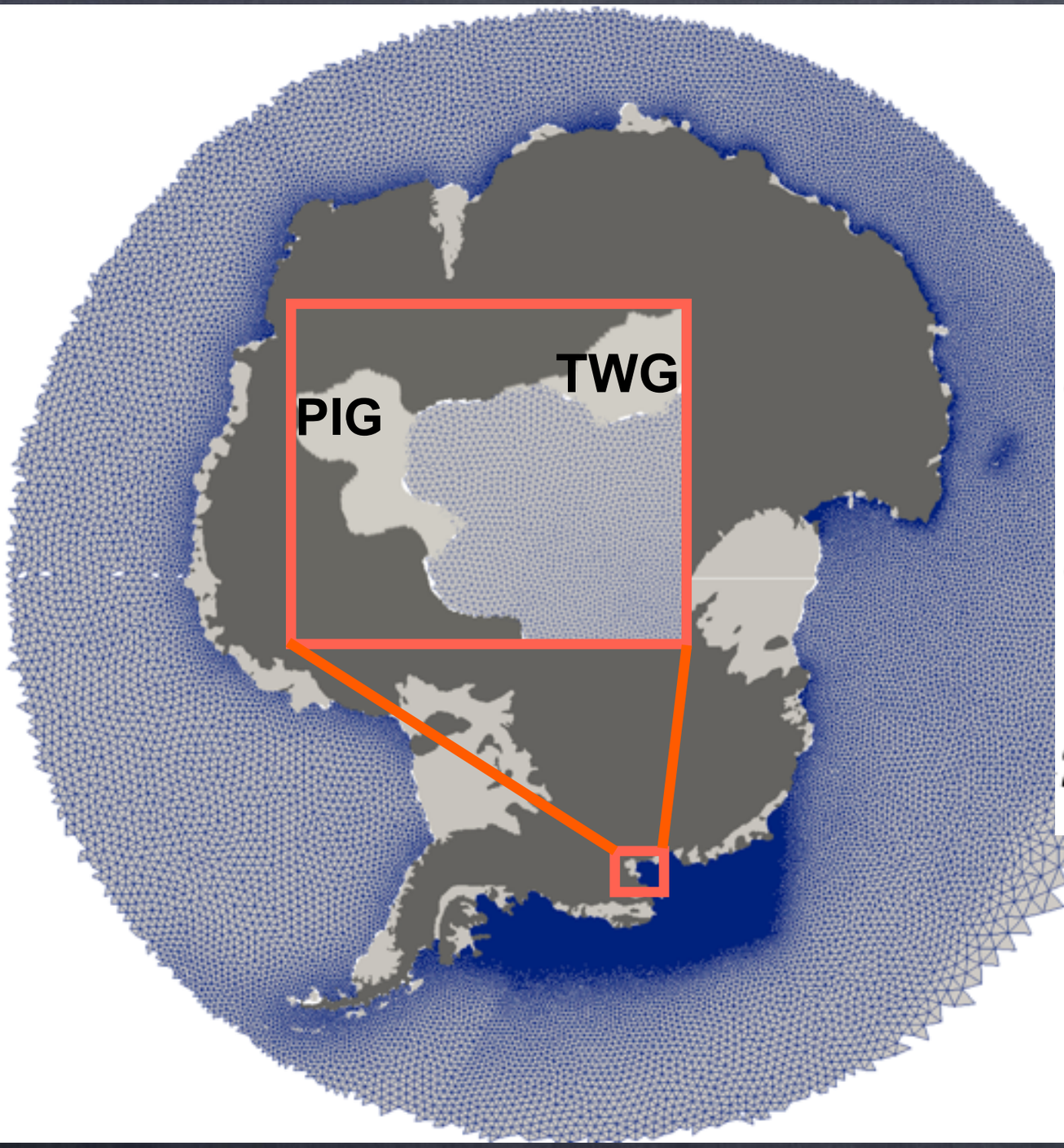
-1

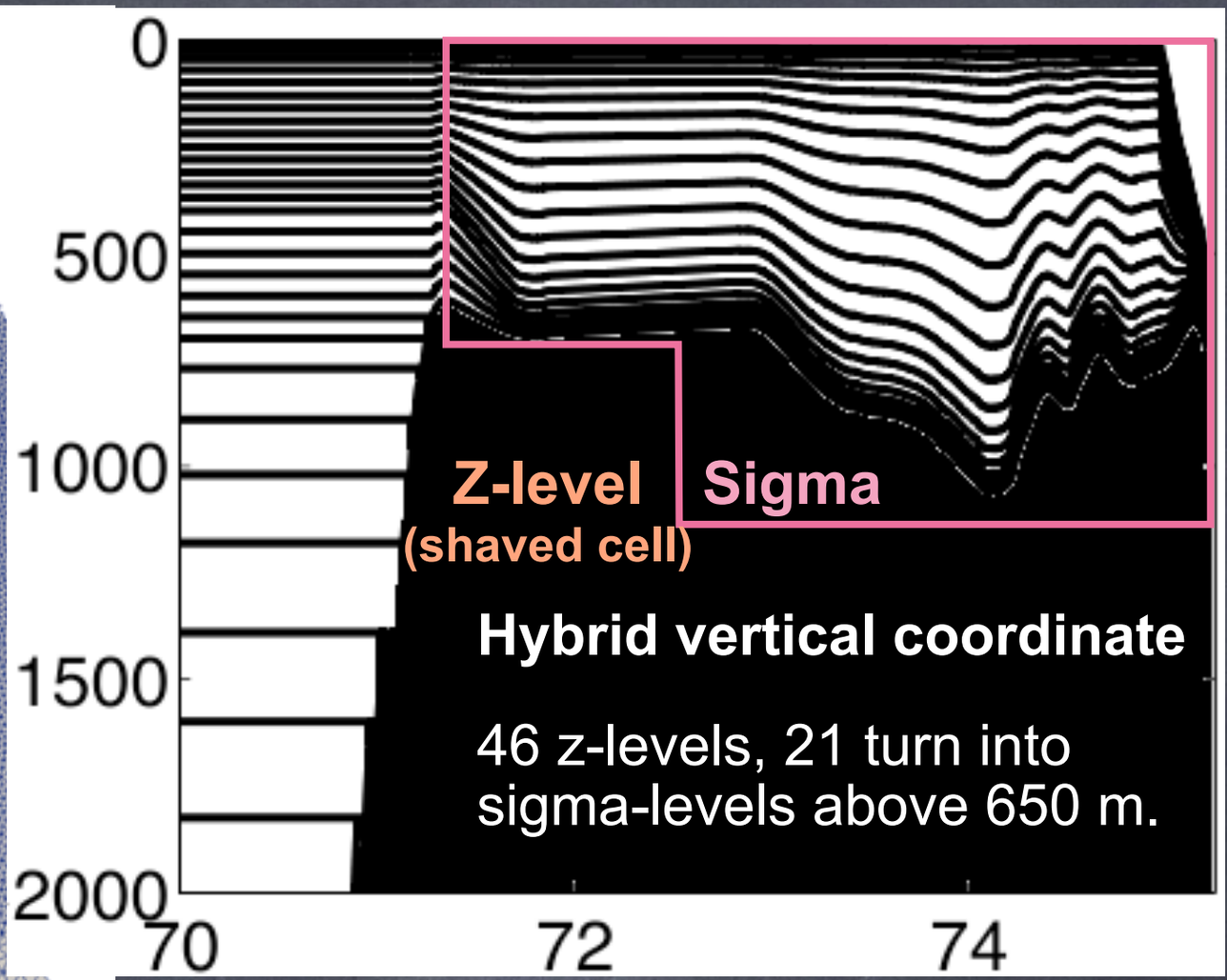
0

-2

1

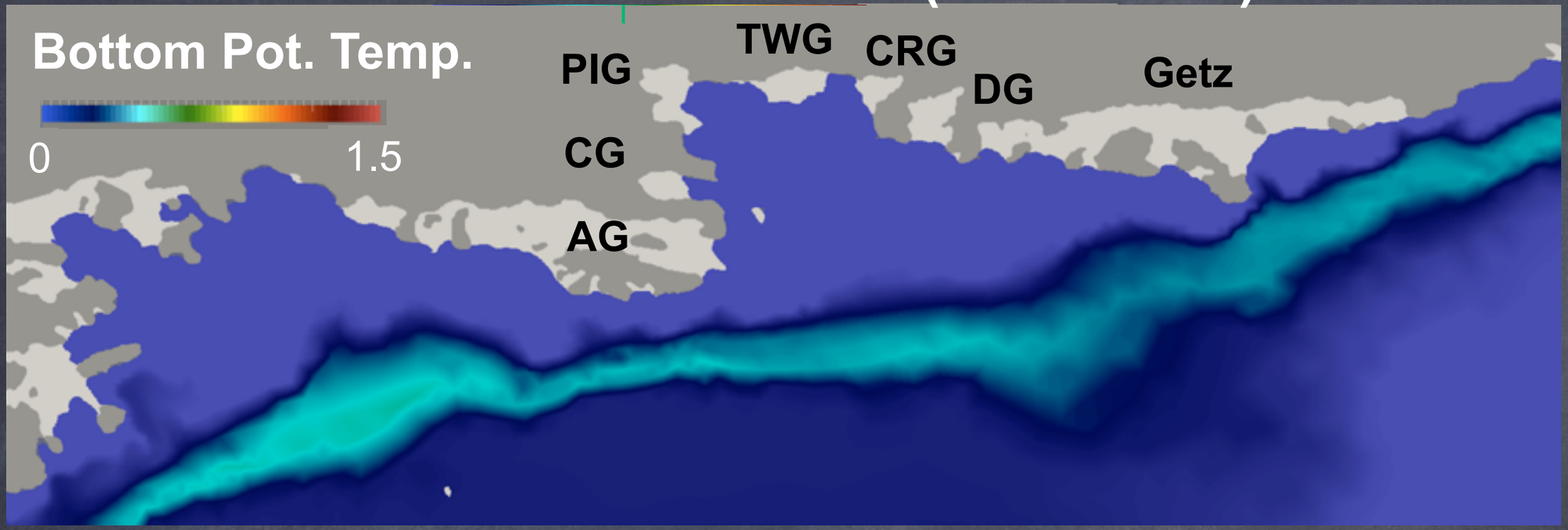
FESOM (Finite Element Sea ice-Ocean Model; Timmerman et al., 2009)





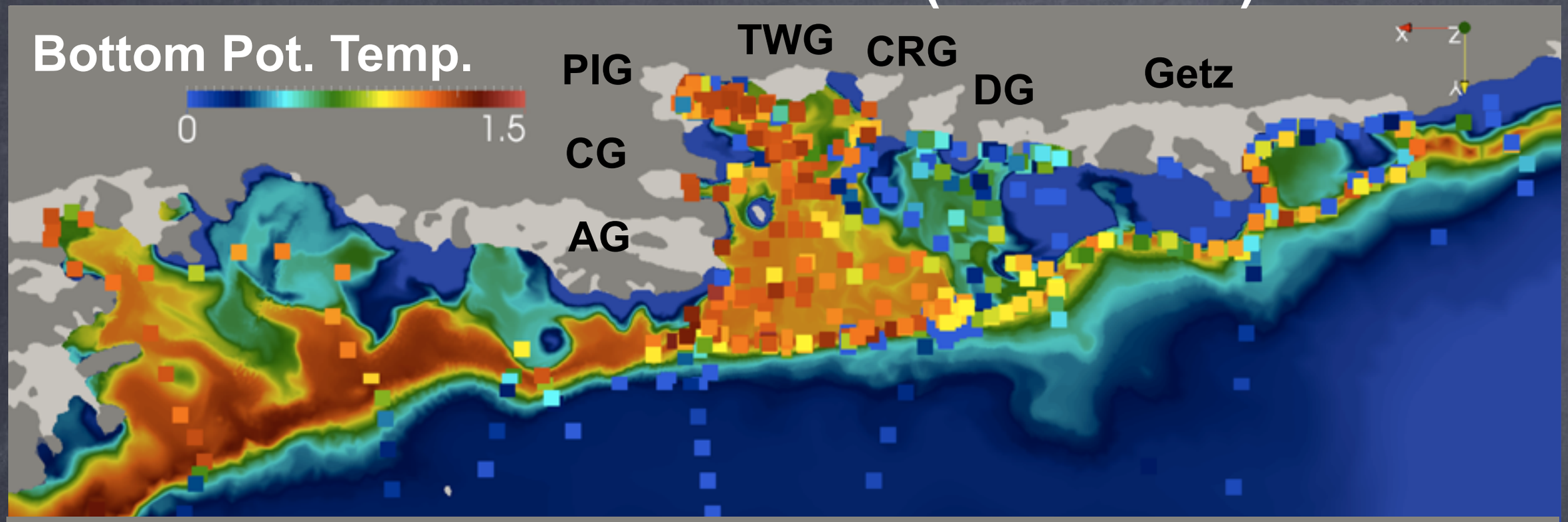
- A **global unstructured mesh** with finer resolutions in the Amundsen Sea (~2 km).
- Rtopo-1 (Timmerman et al., 2010) , NCEP-cfsr forcing (1979-).
- Initialization for 5 years with 1979 forcing.
- T and S restoring in the small region in the Weddell Sea .

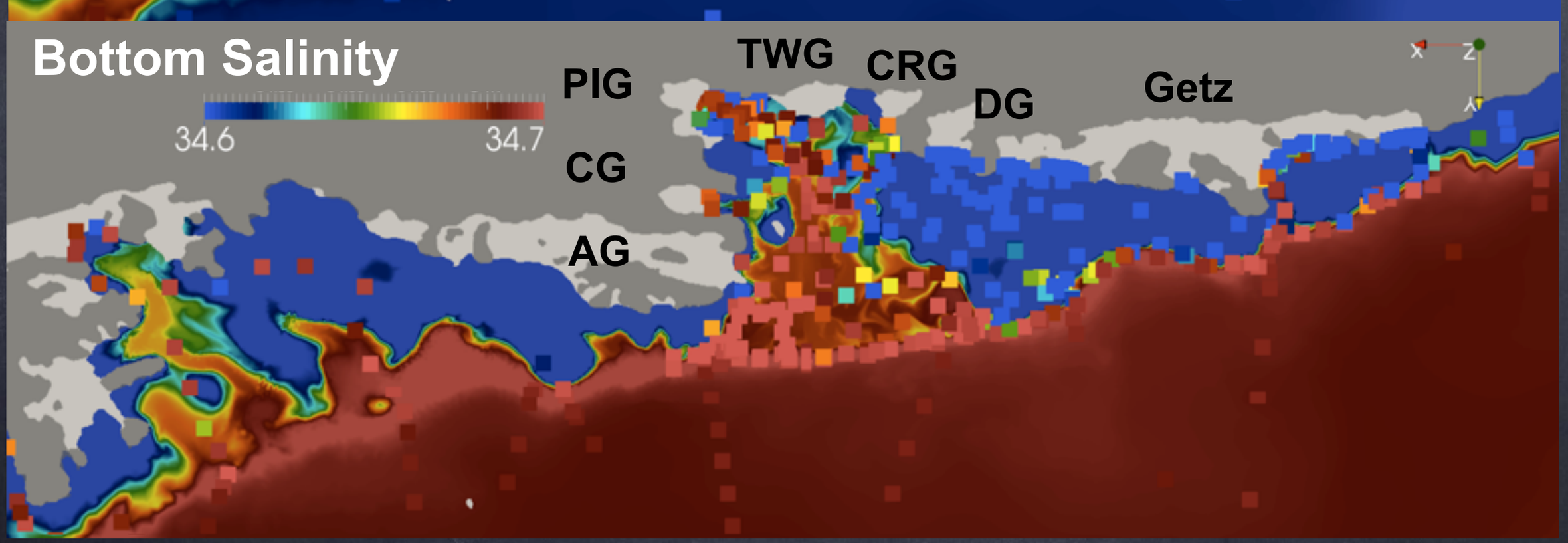
Model Validation 1984 (Year 5 Jan)



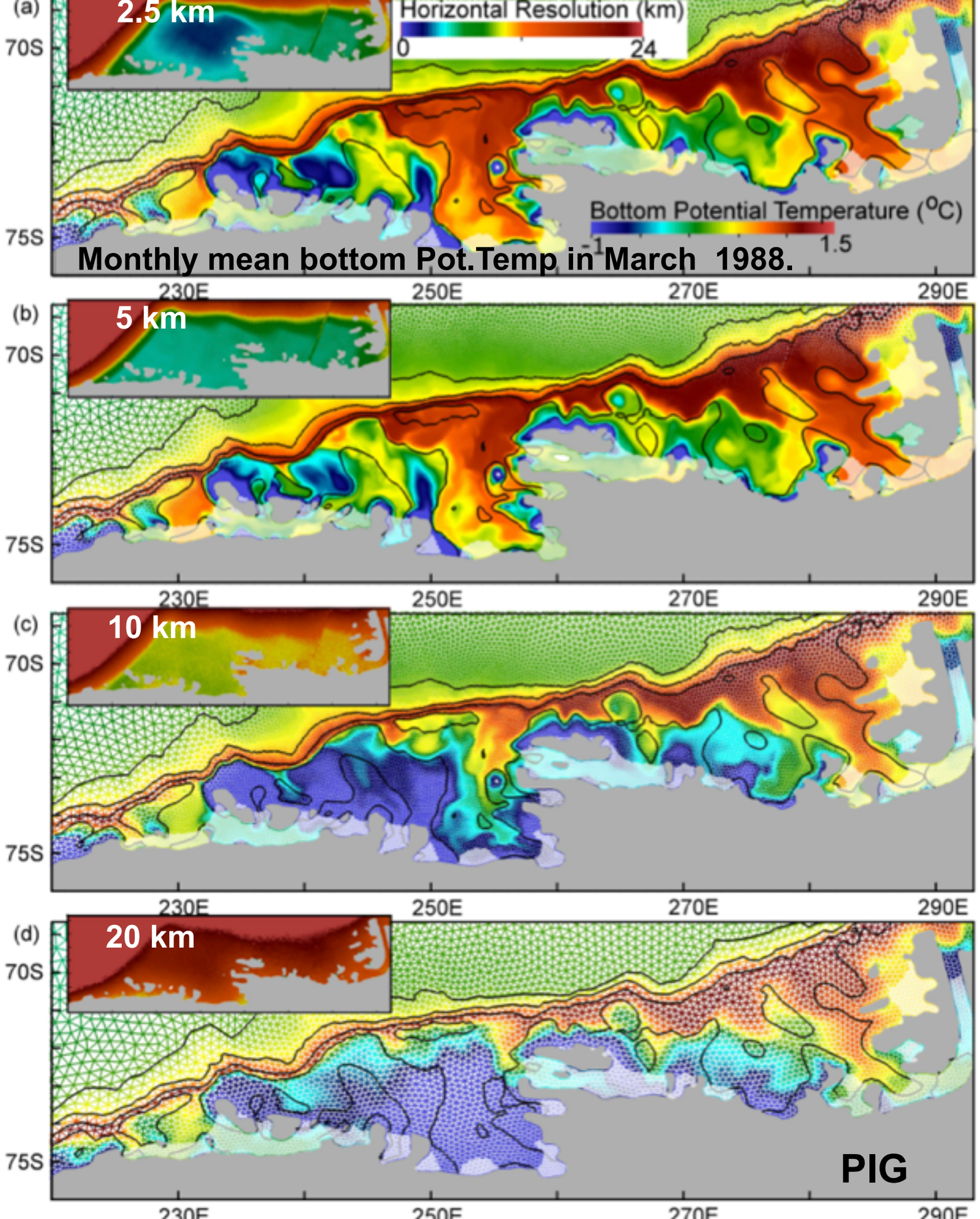
- CDW intrusion is well-reproduced. Slight difference in CDW property PIG ice front, which is colder and less saline (~0.5 ºC, 0.6 psu).

Model Validation 1984 (Year 5 Jan)





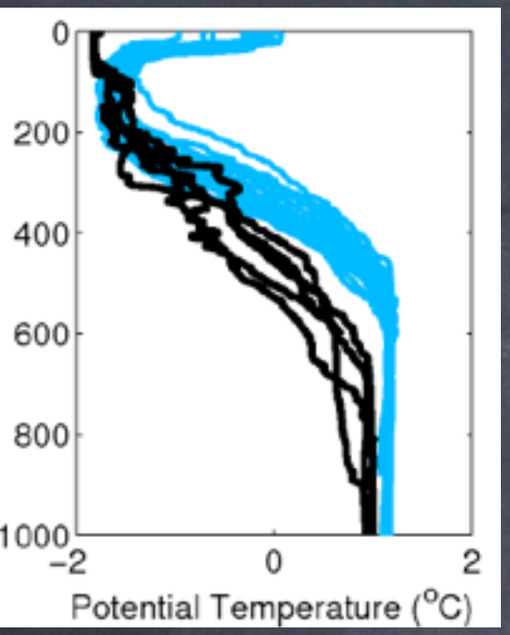
- CDW intrusion is well-reproduced. Slight difference in CDW property PIG ice front, which is colder and less saline (~0.5 ºC, 0.06 psu).

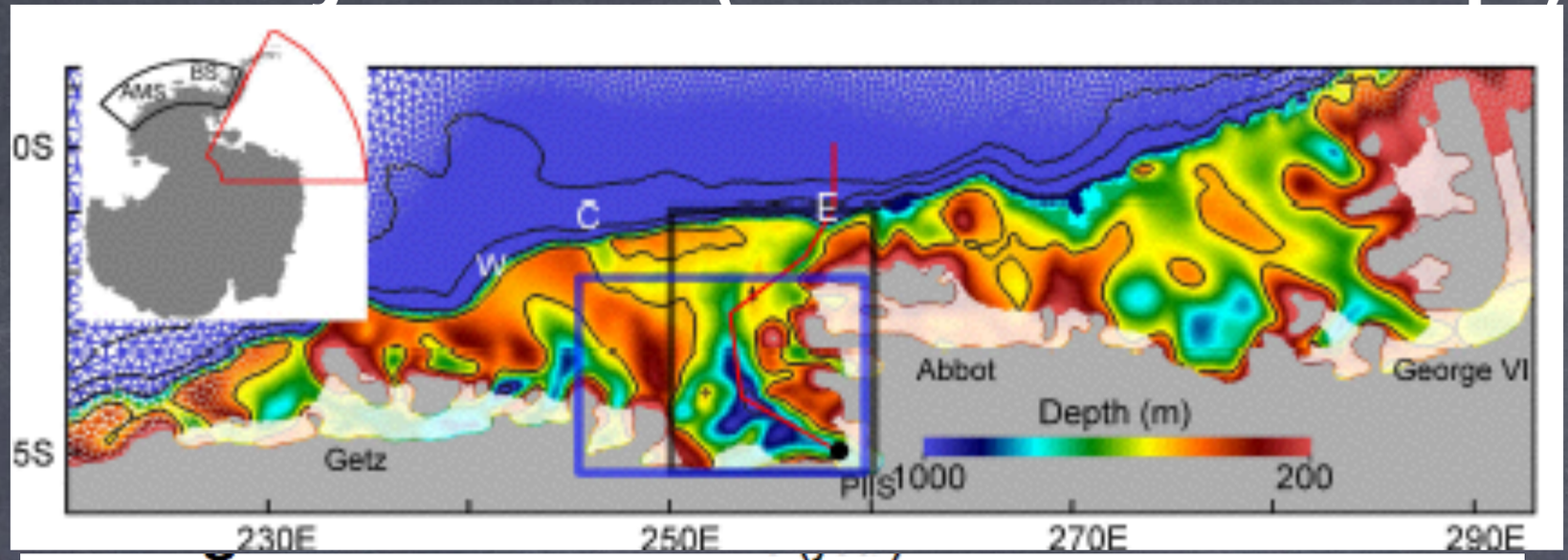

(a)
2.5 km
Horizontal Resolution (km)
0
24
70S
75S
Bottom Potential Temperature (°C)
-1
1.5
Monthly mean bottom Pot.Temp in March 1988.
230E
250E
270E
290E
(b)
5 km
70S
75S
230E
250E
270E
290E
(c)
10 km
70S
75S
230E
250E
270E
290E
(d)
20 km
70S
75S
PIG
230E
250E
270E
290E

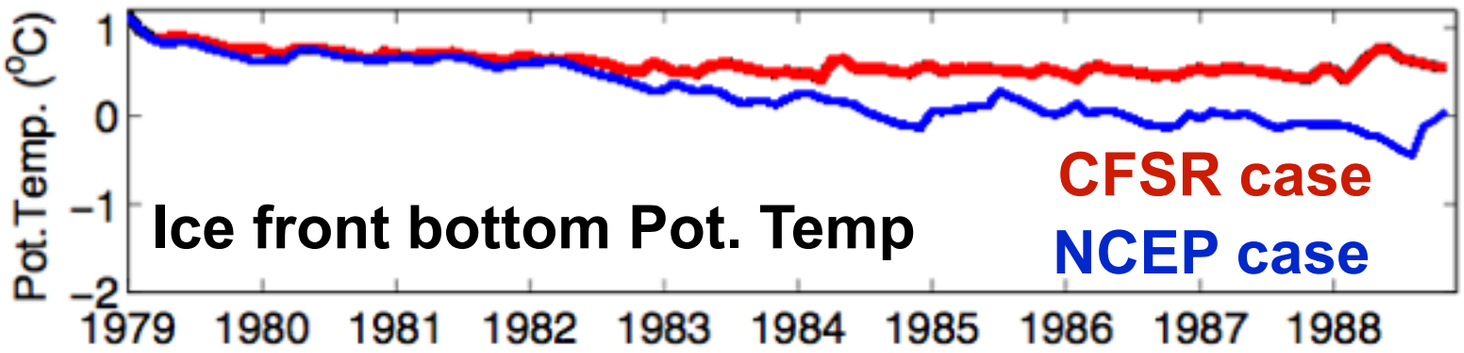
FINE

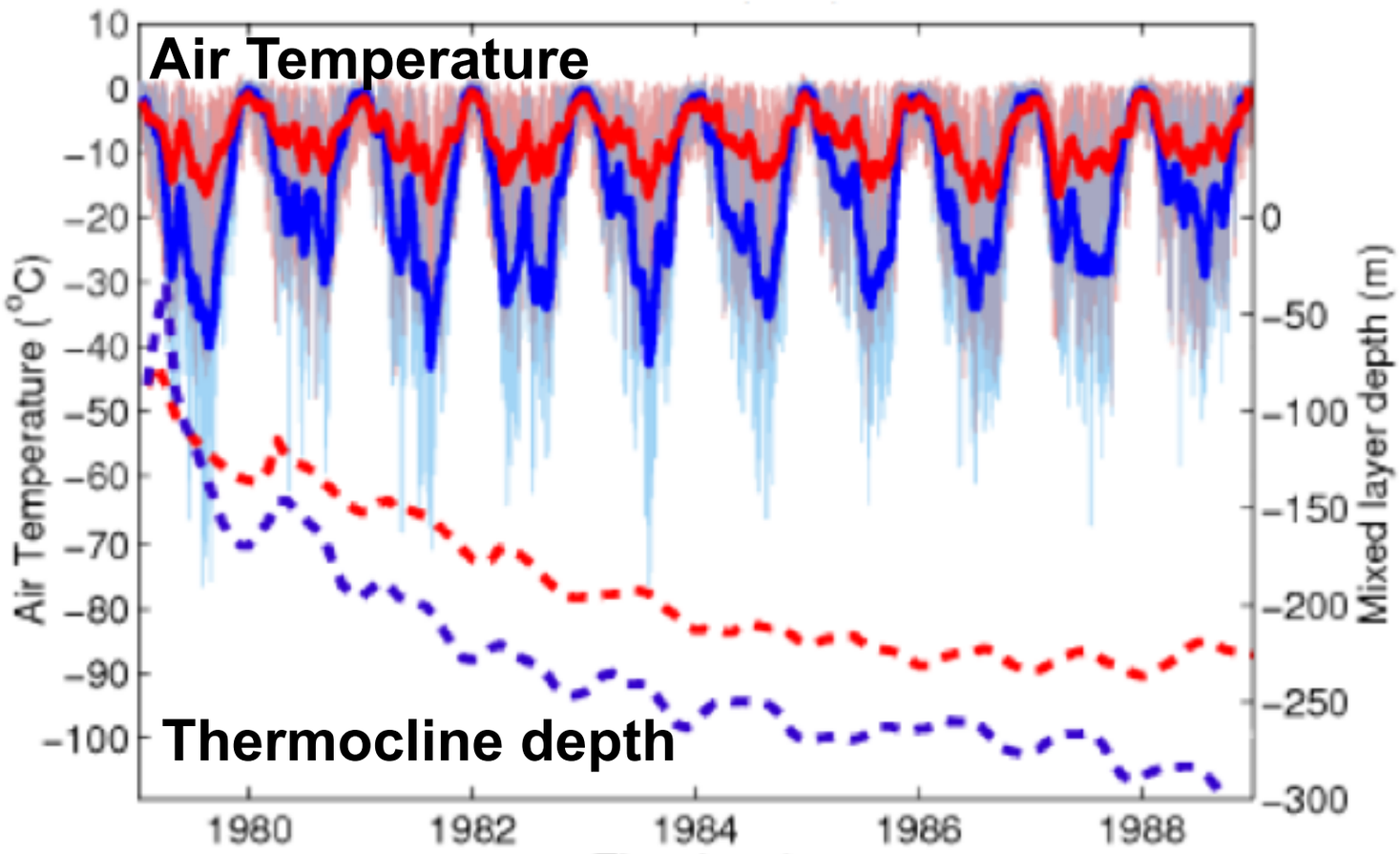
COARSE

Sensitivity studies (ice front Pot. Temp.)

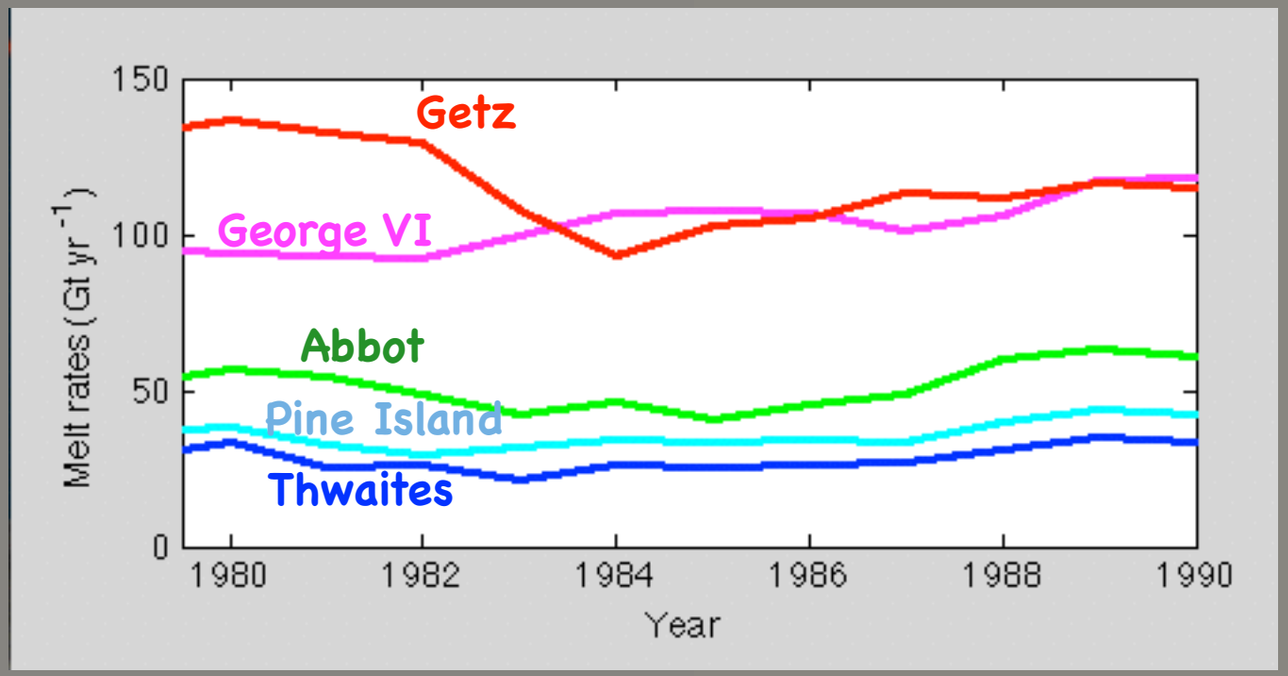








Time series of melt rates (10-year average)



Melt rates (Gt/yr)

Sulzberger+Swinburne 18

Land+ Nickerson 3

Getz 116

Crosson 27

Doston 20

Thwaites 3

Pine Island 34

George VI 100

Stange 22

Venable

Cosgrove 12

Abbot 50

10

5

Bach

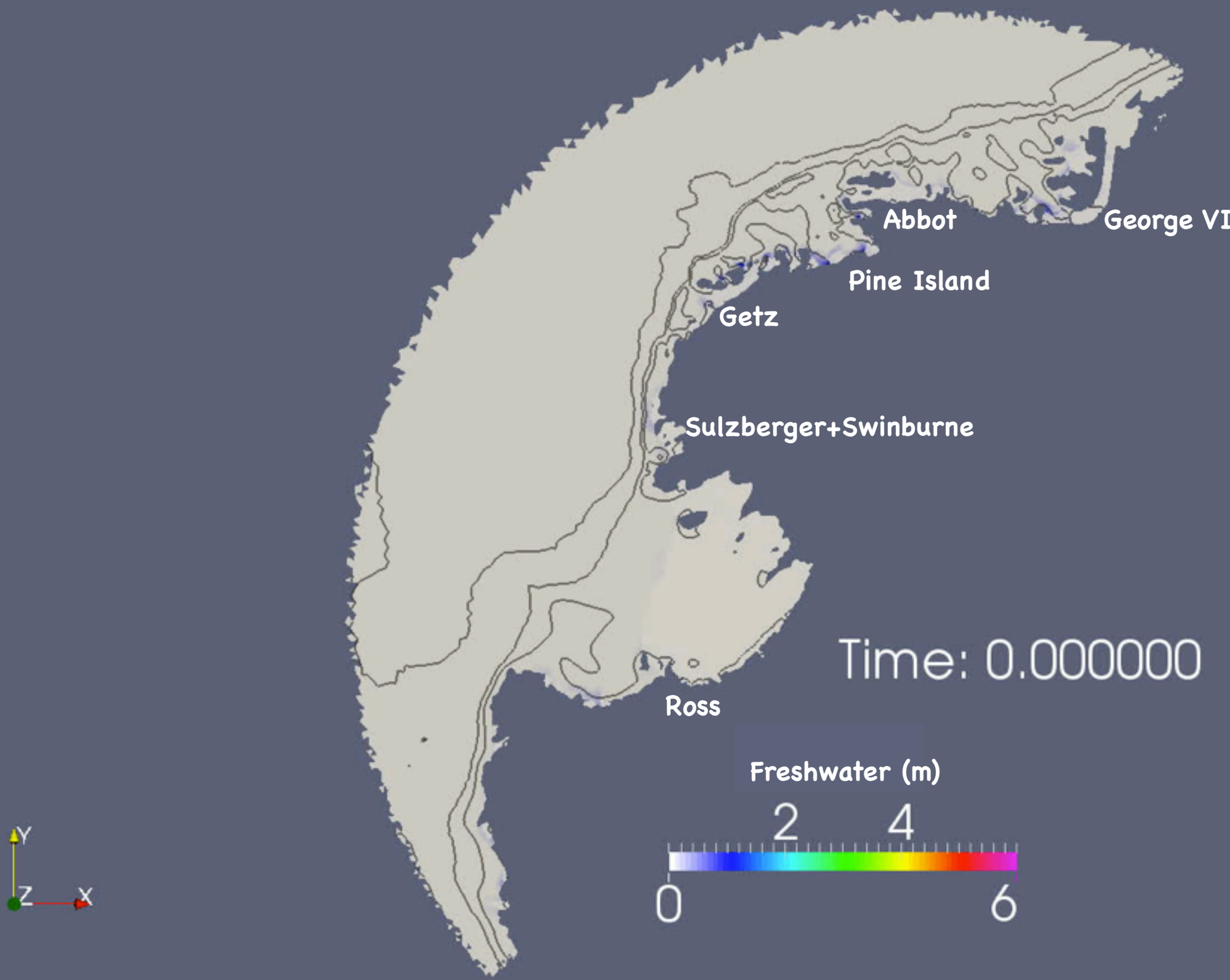
25

Wilkins

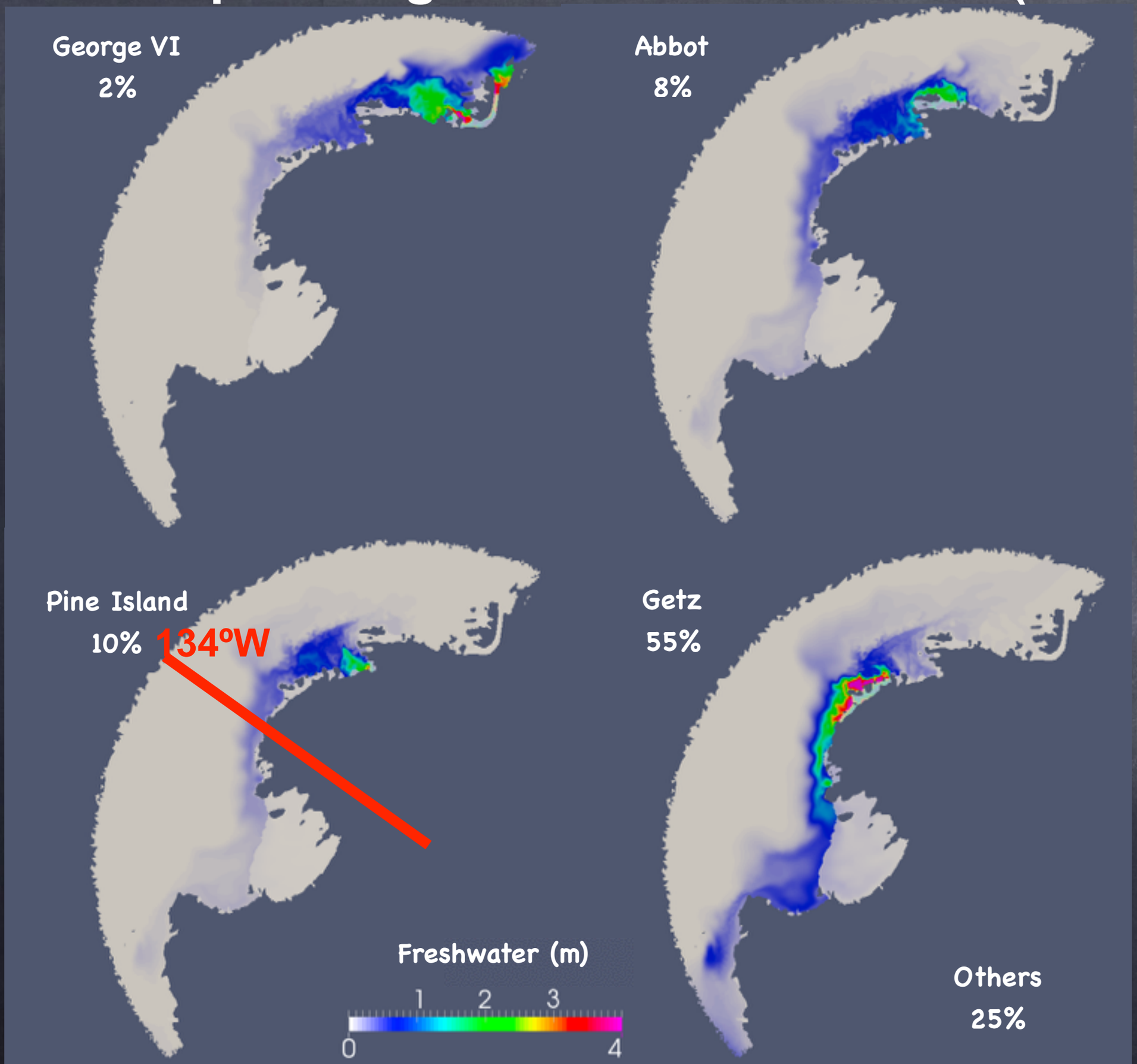
Bellingshausen Sea

Amundsen Sea

Spreading of melt water



Spreading from different source (1989 January).



Sensitivity study : What if CDW gets warmer?

$$F_w = k_m M_{melt}$$

Freshwater and tracer flux from A.S. and B.S. ice shelves

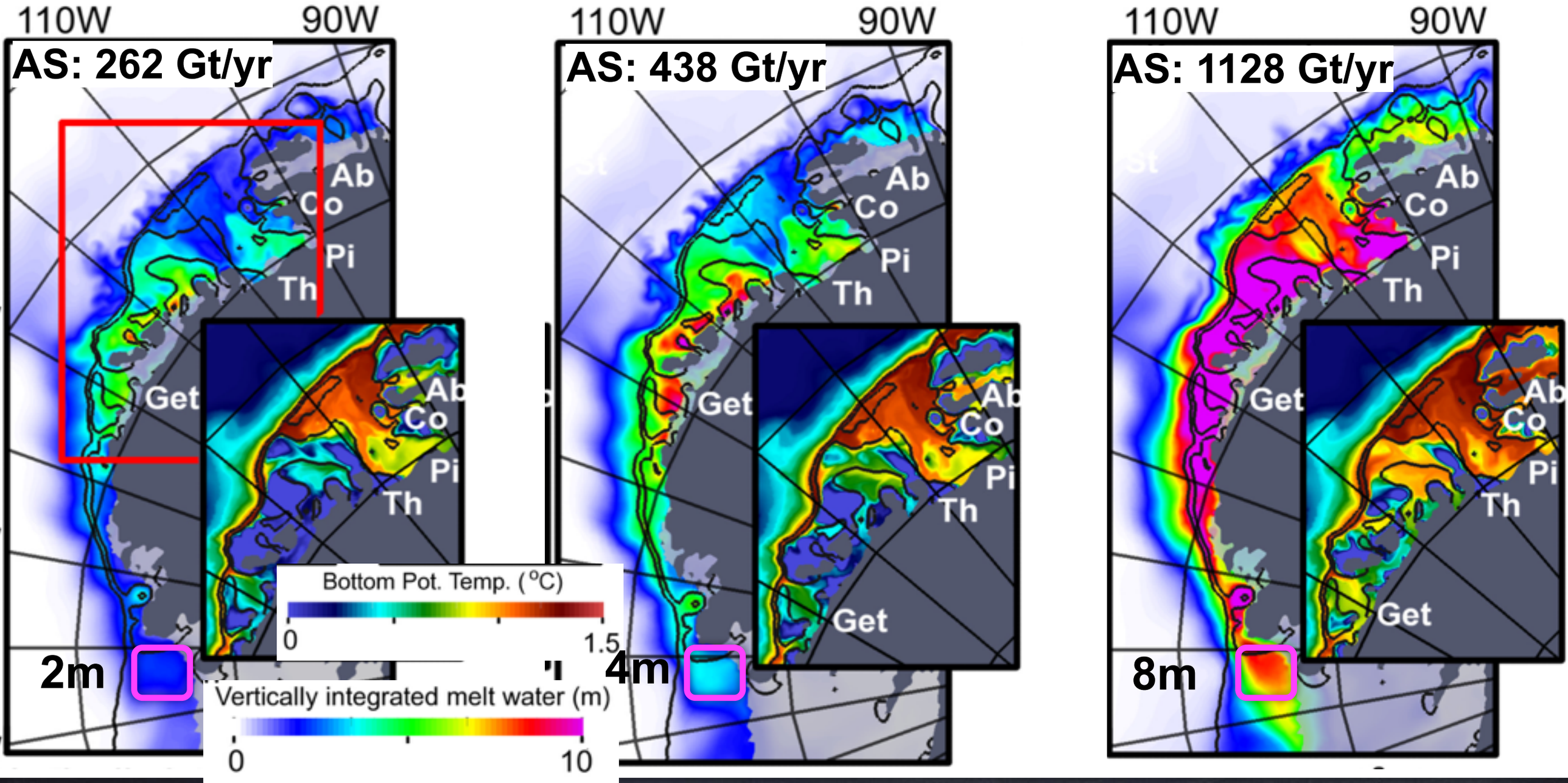
Freshwater flux based on Hellmer 1989 & Jenkins 1991

	Water flux (k_m)	Heat flux	Tracer flux
CTRL	1.0	1.0	1.0
130 Melt	1.3	1.0	1.3
200 Melt	2.0	1.0	2.0

130 Melt: inflow of 0.5ºC → ~0.9ºC

200 Melt: inflow of 0.5ºC → ~2.8ºC

1989 January Tracer from ice shelves in the Amundsen Sea



Summary

- Amundsen Sea is now well-reproduced in FESOM. Inflowing CDW properties are close to the observation. Melt rates of ice shelves in the West Antarctica is mostly consistent with other model results, observations and satellite-based estimates.

- Horizontal resolution of ~5 km is required to simulate realistic CDW intrusion.

- About 1.2 m of glacial melt from West Antarctic ice shelves is transported to the Ross ice shelf front in 10 years.
  George VI : Abbot : Pine Island : Getz = 2% : 8% : 10% : 55%.

- Sensitivity studies show that an increase in basal melting strengthens melt-driven circulation and even increases glacial melt transport into the Ross Sea. This may suggest that a slight increase in intruding CDW temperature can trigger large transport of glacial melt into the Ross Sea.

Sensitivity studies

- Horizontal Resolution
- Horizontal Diffusion
- Forcing (NCEP and NCEP-cfsr)
- Grounded Ice Bergs

Case	CTRL	HG2	HG3	HG4	kh1	kh2	NCEP	Grounded Icebergs
Horizontal grid	HG1	HG2	HG3	HG4	HG1	HG1	HG1	HG1
k_h	0.9	0.9	0.9	0.90	0.45	0.05	0.9	0.9
Forcing	CFSR	CFSR	CFSR	CFSR	CFSR	CFSR	NCEP	CFSR
Grounded Icebergs	off	off	off	off	off	off	off	on

Grounded Ice bergs setting

Fast ice